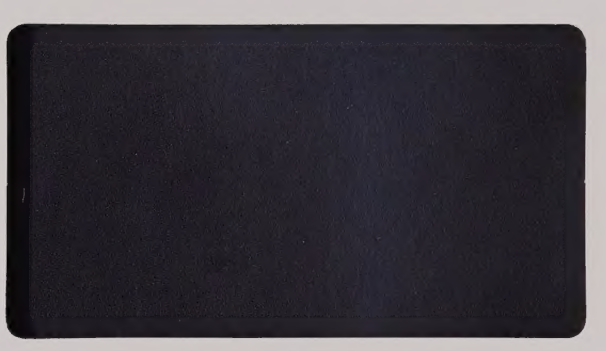
E. S. D. INSTRUMENTATION
C.C. 203 MS 145
RM 2250B EXT 2224

PRELIMINARY
INSTRUCTION MANUAL

MODEL 164
30 MHz
SWEEP GENERATOR

WAVETEK

9045 BALBOA AVENUE, SAN DIEGO, CALIFORNIA



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This preliminary manual is supplied to permit the earliest possible delivery of instruments. A final manual will be supplied when available.

11/73

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This warranty does not apply to any products repaired or altered by persons not authorized by Wavetek, or not in accordance with instructions furnished by Wavetek. If the instrument is defective as a result of misuse, improper repair, or abnormal conditions or operations, repairs will be billed at cost.

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SECTION 1
INTRODUCTION

1.1 PURPOSE OF THE EQUIPMENT

The Model 164 Sweep Generator offers an extended waveform versatility plus a frequency range that spans twelve decades, from 30 μHz (9.2 hours per cycle) to 30 MHz.

The waveforms available are sine, square, triangle, trapezoidal and positive and negative rectangular and trapezoidal pulse, each with variable amplitude, dc offset and symmetry.

The trapezoidal waveform rise and fall times may be varied by means of independent slope, width and symmetry controls. Different rise times and fall times, both controllable, may be selected to suit your testing or triggering requirements.

The Model 164 employs a main generator, which can be triggered, gated or swept by an external signal. In addition, it has a ramp/step generator. The latter is used to sweep, sweep burst or step the frequency of the main generator. Frequency sweeping and stepping may be up or down. Steps may be automatically sequenced or triggered.

1.2 SPECIFICATIONS

1.2.1 Waveforms

Eight selectable waveforms, sine ∿, triangle △, square ⊓, positive pulse ⊔, negative pulse ⊓, trapezoid ⏢, positive trapezoid ⊓, and negative trapezoid ⊔, plus variable DC output. Symmetry of all waveform outputs is continuously adjustable from 1:19 to 19:1. Varying symmetry provides variable duty-cycle pulses, sawtooth or unsymmetrical trapezoidal waveforms. Separate sync output included.

Sweep generator ramp ⟋ and steps ⟋ for continuous or discrete-step sweep; up or down sweeping. The swept signal may be triggered, gated, single stepped or swept-and-held. Main generator frequency may be swept as much as 1000:1.

1.2.2 Operating Frequency Range

Frequency selectable from 0.00003 Hz to 30 MHz in the following ranges.

X 0.001	0.00003 Hz to 0.003 Hz
X 0.01	0.0003 Hz to 0.03 Hz
X 0.1	0.003 Hz to 0.3 Hz
X 1	0.03 Hz to 3 Hz
X 10	0.3 Hz to 30 Hz
X 100	0.3 Hz to 300 Hz
X 1K	3 Hz to 3 kHz
X 10K	30 Hz to 30 kHz
X 100K	300 Hz to 300 kHz
X 1 MHz	3 kHz to 3 MHz
X 10 MHz	30 kHz to 30 MHz

NOTE

When SYMMETRY control is used, indicated frequency is divided by a factor of approximately 10.

1.2.3 Sweep/Step Range

Sweep/step time is selectable from 10 μs to 100 s in the following ranges:

100 s to 10 s	0.01 Hz to 0.1 Hz
10 s to 1 s	0.1 Hz to 1 Hz
1 s to 100 ms	1 Hz to 10 Hz
100 ms to 10 ms	10 Hz to 100 Hz
10 ms to 1 ms	100 Hz to 1 kHz
1 ms to 100 μs	1 kHz to 10 kHz
100 μs to 10 μs	10 kHz to 100 kHz

1.2.4 Outputs

Main Output

Maximum output of sine, triangle, square and trapezoidal waveforms is 20 V p-p into open circuit and 10 V p-p into 50Ω load. Positive and negative trapezoids and pulses are 10 V peak into open circuit and 5 V peak into 50Ω. DC voltage is adjustable between ±10 volts, 50Ω source impedance. Output peak current is 130 mA minimum for all waveforms and DC. Precision output allows from 0 dB to −60 dB attenuation in 10 dB steps with a 20 dB vernier, maximum overall attenuation is −80 dB. High level 0 to

–50 dB and low level –40 to –80 dB outputs give optimum performance.

Sync Output
Approximately 0 to +4 V into open circuit, 50Ω source impedance. Rise and fall times are typically 10 ns into 50Ω load. Sync is a square waveform during symmetrical outputs, rectangular waveform when SYMMETRY control is ON.

Sweep Output
SWEEP OUT connector provides a 0 to +5 V positive ramp from a 600Ω impedance source when SWEEP MODE is RAMP UP or RAMP DOWN, or 0 to +5 V stair step waveform in 10 equal steps when SWEEP MODE is STEP UP or STEP DOWN.

GCV Output
GCV OUT connector provides voltage proportional to main generator frequency from a 600Ω impedance source.

1.2.5 DC Offset

Front panel controlled between ±10 Vdc into open circuit, ±5 Vdc into 50Ω load. Peak voltage output (signal peak plus dc offset) is limited to ±10 V into open circuit, ±5 V into 50Ω load. DC offset and output waveform are attenuated proportionately by the attenuator.

1.2.6 Sweep Modes

Ramp Up
Main generator sweeps linearly from frequency set on front panel to a higher frequency determined by SWEEP WIDTH control at a rate set by SWEEP/STEP TIME control, then returns immediately to start frequency.

Ramp Down
Same as RAMP UP except frequency decreases.

Step Up
Same as RAMP UP except main generator frequency steps up in 10 equal steps.

Step Down
Same as RAMP UP except main generator frequency steps down in 10 equal steps.

1.2.7 Main Generator Operational Modes

Continuous
Operating as a standard VCG (voltage controlled generator), frequency output is determined by front panel control settings in conjunction with external control voltage at VCG IN.

Triggered
Only one complete cycle of output appears at 50Ω OUT connector for each pulse applied to TRIG IN connector (or press of MAN TRIG switch).

Gated
Same as triggered mode except that output oscillations continue for duration of gating signal applied to TRIG IN connector.

Continuous Sweep
Main generator is repeatedly swept in one of the four sweep modes with start and stop frequencies set by the front panel controls.

Triggered Sweep
Main generator oscillates at the frequency set on the front panel. When triggered, it makes one sweep in the selected sweep mode and then returns to the start frequency.

Sweep Hold
Same as triggered sweep except output frequency can be held at final sweep frequency after sweep.

Sweep Burst
Main generator output is a gated swept frequency for the duration of the gate. Between gate signals, output is a dc level.

Single Step
Main generator steps to next one of eleven frequency levels when triggered; eleventh trigger returns output to start frequency.

1.2.8 Voltage Controlled Generator

VCG Control Range
Up to 1000:1 frequency change with external voltage input. Upper frequency is limited to maximum of selected range. Required external signal for full voltage control is 0 to 5 V with input impedance of 5 kΩ.

VCG Slew Rate
2% of range per μs.

VCG Linearity
±0.5% of range.

1.2.9 Triggered Generator

Trigger Input
Trigger pulse is 1 V p-p to ±50 V; input impedance is 10 kΩ, 33 pF; minimum pulse width is 25 ns; maximum repetition rate is 20 MHz.

Start/Stop Point Adjustment
Triggered-signal start/stop point is adjustable:
To 3 MHz . . . . . Approximately −90° to +90°
3 MHz to 30 MHz . . . . Approximately −90° to 0°

1.2.10 Horizontal Precision

Dial Accuracy for Symmetrical Waveforms*
0.0003 Hz to 300 kHz . ±(1% of setting +1% of full scale)
300 kHz to 30 MHz . . ±(3% of setting +2% of full scale)

Frequency Vernier
Electronic frequency vernier precision frequency adjustment is approximately 1% of range.

Time Symmetry*
0.0003 Hz to 30 Hz . . . . . ±1.0%
30 Hz to 300 kHz . . . . . ±0.5%

1.2.11 Vertical Precision

Amplitude Change with Frequency (Sine)
Less than:
0.1 dB to 300 kHz
0.2 dB to 3 MHz
2.5 dB to 30 MHz

Step Attenuator Accuracy
±0.25 dB per 10 dB step.

Stability*
Short term . . . . . ±0.05% for 10 minutes
Long term . . . . . ±0.25% for 24 hours
Percentages apply to amplitude, frequency, and dc offset.

Amplitude Symmetry
All symmetrical waveforms are symmetrical about ground within ±1% of amplitude range up to 3 MHz (e.g. within ±100 mV with output attenuator at 0 dB).

1.2.12 Purity*

Sine Wave Distortion
10 Hz to 100 kHz . . Less than 0.5% (typically 0.25%)
0.0003 Hz to 3 MHz . . . . . Less than 1.0%
3 MHz to 30 MHz . All harmonics at least 26 dB down

Triangle Linearity
0.0003 Hz to 300 kHz . . . . . Greater than 99%

Square Wave Rise and Fall Time
Less than 12 ns (typically 8 ns) when terminated into 50Ω load.

Square Wave Total Aberrations
Less than 5%.

Trapezoidal Rise and Fall Time
Ratio of period to rise or fall time is continuously variable from 2:1 (triangle) to greater than 100:1 and limited to 12 ns (maximum) rise and fall time.

1.2.13 Environmental

Temperature
All specifications listed are for 25°C ±5°C. For operation from 0°C to 55°C, specifications including horizontal precision, amplitude symmetry, and sine wave distortion are derated by a factor of 2.

1.2.14 Mechanical

Dimensions
14½ in./36.8 cm wide; 5¼ in./13.3 cm high; 13½ in./34.3 cm deep.

Weight
13 lb/5.9 kg net; 20 lb/9 kg shipping.

Power
90 to 110 V, 105 to 125 V, 180 to 220 V or 210 to 250 V; 50 to 400 Hz; less than 50 watts.

NOTE

Specifications apply from 10 to 100% of a selected frequency range.

*SYMMETRY control OFF.

SECTION 2
INSTALLATION AND OPERATION

2.1 MECHANICAL INSTALLATION

After unpacking the instrument, visually inspect all external parts for possible damage to knobs, connectors, surface areas, etc. If damage is discovered, file a claim with the carrier who transported the unit. The shipping container and packing material should be saved in case reshipment is required.

2.2 ELECTRICAL INSTALLATION

2.2.1 Power Connection

Connect the ac line cord to the mating connector at the rear of the unit.

NOTE

Unless otherwise specified at the time of purchase, this instrument was shipped from the factory with the power transformer connected for operation on a 105 - 125 Vac line supply and with a 1/2 amp line fuse.

Conversion for 90 to 110 V, 180 to 220 V or 210 to 250 V operation requires resetting two switches on the inside of the rear panel. To reset the switches, unscrew the four captive screws securing the rear panel, and remove the rear panel. Set the two switches and select the fuse for the ac line voltage according to the following table.

AC Line Voltage	Switch A	Switch B	Fuse (SB)
90 - 110	115	LO	½ amp
105 - 125	115	HI	½ amp
180 - 220	230	LO	¼ amp
210 - 250	230	HI	¼ amp

2.2.2 Signal Connections

Use 50Ω shielded cables equipped with female BNC connectors to distribute all signals when connecting this instrument to associated equipment.

The two main outputs, 50Ω OUT (LO) and 50Ω OUT (HI), should be terminated with 50Ω load when used for optimum performance.

2.3 OPERATING CONTROLS

The operating controls and electrical connections for the Model 164 are shown in Figure 2-1. The listing below discusses each control and its function.

1. **POWER Switch** – Power is on when this pushbutton switch is in, and off when extended.

2. **Frequency Index** – The scribe line indicates the frequency dial setting. The index is illuminated when the unit is on.

3. **Frequency Dial** – The main frequency control. The setting on this dial multiplied by the frequency range setting is the basic output frequency of the generator. (The FREQ (Hz) VERNIER, the SYMMETRY control and VCG IN also affect the generator frequency.)

4. **FREQ (Hz) Range** – This 11 position switch selects the generator frequency range, which, when multiplied by the frequency dial setting, determines the basic output frequency of the generator.

5. **FREQ (Hz) VERNIER Control** – This control allows precision control over the output frequency. A complete turn of this vernier is equivalent to approximately one half of the smallest division on the main frequency dial. When in the full clockwise position (CAL), the settings on the main dial will be accurate.

6. **SYMMETRY Control** – The large knob selects a right-hand or left-hand waveform time-symmetry. The small VARIABLE knob varies the waveform time-symmetry up to 19:1 or 1:19. When these controls are used, the frequency range is divided by approximately 10.

   The duty cycle of the square wave can be varied from to ; the slope of the triangle from to ; and the rise to fall time ratio of the trapezoid from to . See

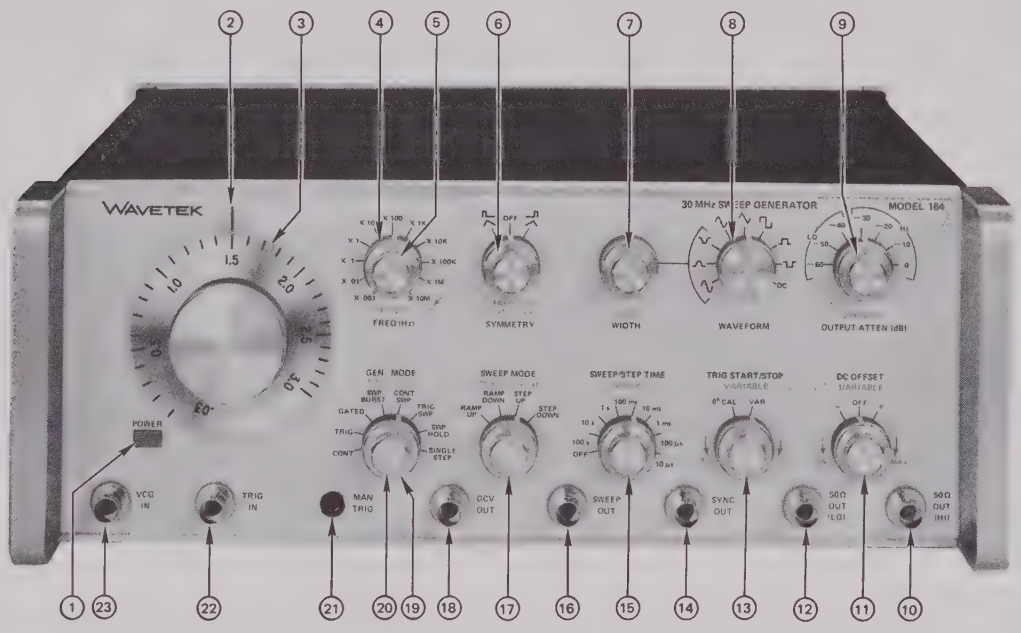


Figure 2-1. Operating Controls and Electrical Connections, Front Panel

Figure 2-2 for the sync signal relationship.

7. **SLOPE/WIDTH Control** – The small knob controls the slope of the trapezoidal waveforms. The large knob controls the time symmetry of the waveform. The setting of these controls does not affect the other waveforms. See Figure 2-2 for the sync signal relationship.

8. **WAVEFORM Selector** – This control selects the waveform that appears at the 50Ω output connector. The waveforms are sine ∿, triangle △, square ⊓, positive going rectangular pulse ⎍, negative going rectangular pulse ⎓, trapezoidal ⏢, positive going trapezoidal pulse ⏠, negative going trapezoidal pulse ⏡, and DC voltage.

9. **OUTPUT ATTEN (dB) Control** – The large knob attenuates the 50Ω output from 0 dB (10 V p-p max into 50Ω load) to –60 dB (10 mV p-p into 50Ω) in 10 dB steps. LO and HI indicate the correct output connector to use. The small VARIABLE knob may be used to continuously change the amplitude by approximately 20 dB. Maximum attenuation is –80 dB (1.0 mV p-p into 50Ω). The OUTPUT ATTEN (dB) VARIABLE control is inoperative when DC is selected on the WAVEFORM selector.

10. **50Ω OUT (HI)** – This is the selected waveform

NOTE: VARIABLE SYMMETRY OFF

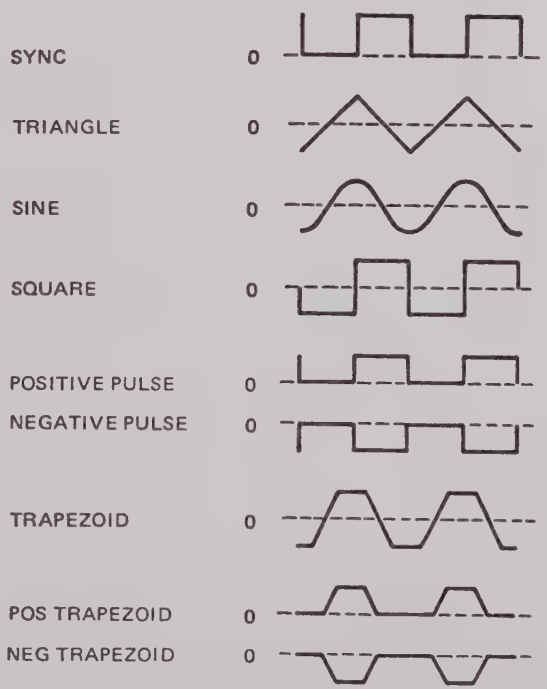


Figure 2-2. Selectable Waveforms and Sync Signal Phase and Polarity Relationships

output for the main generator or a dc voltage when the OUTPUT ATTEN (dB) switch is set 0 to −30 dB. The Model 164 operating into an open circuit provides 20 V p-p maximum, or into a 50Ω load provides a 10 V p-p output for the sine, triangle, square and trapezoidal waveforms; maximum trapezoidal and rectangular pulses are 10 V into an open circuit and 5 V into a 50Ω load.

11. **DC OFFSET Control** – Adjusts dc base line offset above (+) or below (−) signal ground; or, when DC is selected on the WAVEFORM selector, adjusts dc voltage at the 50Ω output. The large knob selects polarity, and the small VARIABLE knob adjusts voltage up to ±10 Vdc into an open circuit (±5 Vdc into 50Ω load).

    Peak signal output (waveform plus dc offset) is limited to ±10 Vdc into an open circuit (±5 Vdc into a 50Ω load). (The OUTPUT ATTEN (dB) control affects dc offset as well as waveform amplitude.)

12. **50Ω OUT (LO)** – This is the selected waveform output for the main generator or a dc voltage when the OUTPUT ATTEN (dB) control is set −40 dB to −60 dB.

13. **TRIG START/STOP Control** – The large knob switched to VAR allows the triggered output signal start and stop point to be varied by turning the small knob. For sine and triangle waveforms, the start/stop point may be varied from negative peak voltage to almost positive peak voltage. (At the higher frequencies, the limits are negative peak to waveform zero level.) The square wave always starts/stops at negative peak voltage. The rectangle pulses always start/stop at waveform zero level. The trapezoidal waveform start/stop points are continuously variable. When the large knob is set to 0° CAL, sine and triangle waveforms start/stop at waveform zero level; square and positive rectangular pulse waveforms start/stop at negative peak level; trapezoidal and trapezoidal pulse waveform start/stop points vary with the SLOPE/WIDTH control settings.

14. **SYNC OUT** – This is a square wave (or rectangular if SYMMETRY control is in use) with the same frequency and same polarity of the selectable square wave at a 50Ω output. Amplitude into an open circuit is greater than 4 V p-p (2 V p-p into 50Ω). See Figure 2-2.

15. **SWEEP/STEP TIME Control** – When operating in any of the sweep modes, this control determines the duration of the sweep or a single step by controlling the frequency of the sweep generator, which is independent of the frequency of the main generator. The large knob selects the range, which is bounded by the time values printed on the control panel on either side of the detent setting. The small VARIABLE knob varies the time throughout the range; rotating the VARIABLE knob ccw increases the sweep time at least by 10:1.

16. **SWEEP OUT** – This output provides a fixed 0 to nominal +5 V sawtooth or 10-step waveform, depending on the ramp or step sweep mode. The frequency of these waveforms is controlled by SWEEP/STEP TIME.

17. **SWEEP MODE/SWEEP WIDTH Control** – The large knob selects one of the step or ramp sweep signals. The small knob determines the amplitude of the sweep signal fed to the main generator, thereby determining the bandwidth of frequencies swept when in a sweep mode.

18. **GCV OUT** – This is Generator Control Voltage output, a voltage proportional to the generator output frequency.

19. **GEN MODE Switch** – Selects the operating mode of the main generator (50Ω OUT) as follows:

    a. CONT Mode – The generator operates continuously as a standard Voltage Controlled Generator (VCG). Frequency output is determined by front panel control settings in conjunction with external control voltage at VCG IN.

    b. TRIG Mode – The generator will give one complete cycle of output when the MAN TRIG is pressed or for each cycle of signal applied to TRIG IN. The generator output cycle begins and ends as determined by the TRIG START/STOP control. Since the internal sweep operates independently it can be used to provide a repetitive trigger signal by connecting the SWEEP OUT to TRIG IN.

    c. GATED Mode – Operates the same as TRIG mode except that the generator will continue to have output for the full time that the MAN TRIG switch is held down or the gate signal at TRIG IN exceeds the gating level set by the TRIG LEVEL control.

    d. SWP BURST Mode – When MAN TRIG is pressed or a pulse is applied to TRIG IN, both the main generator and sweep operator are triggered; the

main generator sweeps and holds if the gate is longer than the sweep generator period or sweeps once if the gate is shorter than the sweep period. The 50Ω OUT signal exists only for the duration of the gate. Sweep characteristics are determined by the sweep controls. See Figures 2-12 and 2-13 for signal characteristics in SWP BURST mode.

e. CONT SWP Mode — The main generator operates continuously and is repetitively swept. Sweep characteristics are determined by the sweep controls.

f. TRIG SWP Mode — The main generator oscillates at the start frequency until a trigger signal is applied. The frequency then sweeps to the frequency determined by the SWEEP WIDTH control and then returns to the start frequency until another trigger is applied.

g. SWP HOLD Mode — The main generator oscillates at the start frequency until a gate signal is applied to the TRIG IN connector. The main generator then sweeps from the start frequency to the frequency determined by the SWEEP WIDTH control and remains at that frequency for the duration of the gate signal. When the gate falls, the generator returns to the start frequency. If the gate is quicker than the sweep, this mode is identical to TRIG SWP mode.

h. SINGLE STEP Mode — This mode is to be used in conjunction with STEP UP (or DOWN) on the SWEEP MODE control. The main generator oscillates at a start frequency until triggered. When MAN TRIG is pressed or a signal is applied to TRIG IN, the frequency output steps to the first of 10 levels determined by the SWEEP WIDTH control. Each successive trigger steps the frequency to another level. On the eleventh trigger, the frequency returns to start frequency.

20. **TRIG LEVEL Control** — A continuously variable adjustment of the TRIG IN circuitry. When full ccw, approximately a positive going pulse of +7.5 V (A, Figure 2-3) or greater voltage is required for triggering. In the full cw position, a positive going pulse of approximately −7.5 V (B, Figure 2-3) or more positive voltage is required for triggering. In the GATED mode, the generator will begin to run continuously at some position of the control cw past 12 o'clock. When using the MAN TRIG, this control must be ccw of the midpoint.

21. **MAN TRIG Switch** — When in any of the trigger modes, pressing this switch furnishes the trigger. When in any of the gate modes, this switch furnishes the gate signal for the duration that it is pressed and held down. The TRIG LEVEL control must be ccw from midpoint for proper MAN TRIG operation.

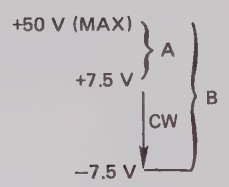


Figure 2-3. Range of Triggering Voltage

22. **TRIG IN** — A dc coupled input with 10 kΩ, 33 pF input impedance. The TRIG LEVEL control adjusts the sensitivity of the generator to this input signal. Trigger signals must be 1 V p-p or greater but within the range of ±50 V. Trigger signal width must be 25 ns or greater. Trigger frequency must be less than 20 MHz.

23. **VCG IN** — This connector allows external control of frequency. With 0 volt in, the basic generator frequency (50Ω OUT) is determined by the frequency range selected and the frequency dial setting. A positive VCG voltage will increase this frequency, and a negative voltage will decrease the frequency. Input impedance is 5 kΩ. Restrictions for linear operation are (1) the upper frequency limit is the value selected with the FREQ (Hz) switch, (2) the lower frequency limit is one-thousandth the value selected with the FREQ (Hz) switch. A 5-volt excursion covers the 1000: 1 frequency range.

2.4 INSTALLATION CHECKS

The following procedures are used to determine that the instrument is operating properly. Field calibration and checkout instructions (to be supplied) are to be used to ensure that the instrument complies with the specifications. If the instrument is not operating properly or within specifications, refer to the warranty on the back of the title page.

Use a Tektronix Model 454 oscilloscope (or equivalent) and a Counter-Timer when performing these installation checks.

1. After connecting the line cord to the ac line, set the front panel controls and switches as follows:

POWER	In
Frequency Dial	1.0
FREQ (Hz) Range	X 1K
FREQ (Hz) VERNIER	Fully Clockwise
SYMMETRY	OFF
WAVEFORM	⊓
OUTPUT ATTEN (dB)	0
OUTPUT ATTEN (dB) VARIABLE	Fully Clockwise
DC OFFSET	OFF
TRIG START/STOP	0° CAL
SWEEP/STEP TIME	OFF
GEN MODE	CONT

2. Connect the 50Ω OUT (HI) connector with a shielded cable terminated in a 50 ohm load to the oscilloscope and set FREQ (Hz) VERNIER to obtain 1 kHz display on the oscilloscope. Approximately 10 V p-p should be displayed.

3. Rotate OUTPUT ATTEN (dB) VARIABLE control full ccw. Increasing signal attenuation should be observed. Return to full cw.

4. Set SLOPE control (small knob) full cw and WIDTH control (large knob) at approximately midpoint.

5. Check amplitudes of sine ∿ , triangle △ and trapezoidal ⊓ waveforms. They should be approximately 10 V p-p.

6. Use SLOPE/WIDTH control to vary the slope and time symmetry of the trapezoidal waveform.

7. Check minimum and maximum amplitudes of positive and negative pulse waveforms, both rectangular and trapezoidal. Amplitudes should be approximately 5 volts above or below the 0 volt level.

8. Switch the FREQ (Hz) range control to check range-to-range tracking accuracy. The oscilloscope should show approximately the FREQ (Hz) range value.

9. Select the square waveform and rotate the SYMMETRY switch to ◿ and the VARIABLE control full cw. Waveform asymmetry should be approximately 19:1. Rotate the VARIABLE control full ccw; the waveform should be symmetrical. Verify that the other switch position and VARIABLE control give approximately 1:19 waveform asymmetry.

10. Turn the SYMMETRY switch to OFF and select DC on the WAVEFORM selector. Use a shielded cable with BNC connectors to connect SYNC OUT to the oscilloscope trigger input.

11. Set the DC OFFSET switch to + and rotate the VARIABLE control full cw. The amplitude should be approximately +5 V into a 50Ω load.

12. Set the DC OFFSET switch to −. Amplitude should be approximately −5 V.

13. Rotate the OUTPUT ATTEN (dB) switch thru each position. Verify the attenuation on the oscilloscope. (The VARIABLE control is inoperative for DC.) Repeat using 50Ω OUT (LO) connector.

14. Turn the DC OFFSET switch to OFF and connect the SWEEP OUT to the oscilloscope without a load. Set SWEEP MODE switch to RAMP UP. With the SWEEP/STEP TIME switch set to 10 ms I 1 ms and the VARIABLE control set full cw (1 ms sweep), verify that the SWEEP OUT waveform is approximately a 1 kHz sawtooth. (RAMP DOWN position gives the same positive going sawtooth waveform.)

NOTE

The SWEEP/STEP TIME VARIABLE control is not calibrated.

15. Set the VARIABLE control full ccw. The SWEEP OUT waveform should be approximately 100 Hz.

16. Check the SWEEP OUT frequency in all positions of the SWEEP TIME switch and at both the cw and ccw ends of the VARIABLE control.

17. Change SWEEP MODE switch to observe stair steps up. (Both STEP UP and STEP DOWN give the same positive going waveform.) Notice that the SWEEP/STEP TIME setting is the duration of each step.

18. Set the WAVEFORM selector to ∿ , the SWEEP MODE switch to STEP UP, the SWEEP/STEP TIME switch to 10 s I 1 s, and the VARIABLE control to full cw (1 s sweep). Use a shielded cable equipped with BNC connectors and connect SWEEP OUT to VCG IN. Connect the oscilloscope to 50Ω OUT (HI) and observe the stepping of the output frequency.

19. Remove the cable from VCG IN and connect TRIG IN to SWEEP OUT. Set SWEEP MODE to RAMP UP. Set the GEN MODE switch to TRIG and the SWEEP/STEP TIME switch to 100 ms I 10 ms. Rotate the

TRIG LEVEL near 12 o'clock. The oscilloscope should display one cycle of the waveform each time the sweep output triggers the main generator.

20. Set the GEN MODE switch to GATED and rotate the TRIG LEVEL control while observing the oscilloscope. The multiple cycles of the selected output waveform should appear when the TRIG LEVEL control is rotated cw and reduce to one cycle, then none, when the control is turned ccw. At some point ccw the generator stops oscillating, and at some point cw it goes into continuous operation.

21. Turn SWEEP/STEP TIME switch to OFF. Use MAN TRIG switch to gate waveforms. Waveforms should be continuous when MAN TRIG switch is held down.

22. Set the GEN MODE switch to TRIG. Use MAN TRIG switch to trigger waveforms. One cycle should appear each time the trigger is pressed.

23. Turn SWEEP/STEP TIME switch to 10 ms ▮ 1 ms and GEN MODE switch to GATED. Set TRIG START/STOP switch to VAR and rotate VARIABLE knob full cw. Observe the start/stop point of the waveform. Rotate the VARIABLE knob and trigger waveforms to observe the varying start/stop points. At full cw the waveform should start/stop at approximately +90° (positive peak); at full ccw, approximately −90° (negative peak); and at midpoint, 0°. (TRIG LEVEL may require adjusting.) Set TRIG START/STOP switch to 0° CAL. Disconnect the cable to TRIG IN.

NOTE

Steps 24 and 25 set low and high frequencies of the sweep range.

24. Set the GEN MODE switch to SWP HOLD, TRIG LEVEL control to 9 o'clock, FREQ (Hz) range to X 10K, SWEEP/STEP TIME switch to 10 s ▮ 1 s and SWEEP MODE switch to RAMP UP. With a counter, the frequency dial and FREQ (Hz) VERNIER control, set the frequency to 30 Hz.

25. Rotate the TRIG LEVEL control to 3 o'clock (triggering the generator) and rotate the SWEEP WIDTH control to set the frequency to 30 kHz.

26. Rotate the TRIG LEVEL control to 9 o'clock, and the GEN MODE switch to CONT SWP. Output should be the 30 to 30 kHz swept signal continuously repeating.

27. Set GEN MODE switch to TRIG SWP and press the MAN TRIG switch. The generator output should be the swept signal occurring once for each trigger.

28. Set the GEN MODE switch to SINGLE STEP and SWEEP MODE switch to STEP UP. Press the MAN TRIG ten times while observing the stepped increase in output frequency. The eleventh trigger should return the frequency to 30 Hz.

29. Remove the cable from 50Ω OUT and connect to GCV OUT. Connect SYNC OUT to the oscilloscope trigger input. Trigger the generator as in the previous step. Observe the varying voltage corresponding to the varying frequency output. Reconnect the cable to 50Ω OUT (HI).

30. Set the GEN MODE switch to SWP BURST and press the MAN TRIG switch and hold. A frequency stepping and hold should occur. When the switch is released, no signal should be present.

2.5 OPERATING PROCEDURE

No preparation for operation is required beyond completion of the initial installation checks given in Paragraph 2.4 of this manual. It is recommended that a one-half hour warm-up period be allowed for the associated equipment to reach a stabilized operating temperature, and for the Model 164 to attain stated accuracies.

There are almost unlimited ways to set up the generator and waveforms that may be obtained. The following sections describe basic configurations and how to set them up.

2.5.1 Operation as a Function Generator

1. Depress the POWER switch. Properly terminate the 50Ω OUT (HI) connector.

2. Set the GEN MODE switch to CONT.

3. Set the FREQ (Hz) range switch to the desired multiplier.

4. Set the frequency dial to the desired setting. Use the frequency VERNIER for precision frequency setting if necessary.

5. Select desired basic output waveform using the WAVEFORM selector.

6. Set OUTPUT ATTEN (dB) switch for desired output

level and amplitude. If a LO amplitude signal is selected, use the 50Ω OUT (LO) connector.

For reference, the following table gives the approximate output amplitude levels at attenuator settings. The output levels of the positive and negative pulse waveforms are one-half of these levels.

TABLE 2-1

Attenuator Position	Peak-to-Peak Output into 50Ω Load	
	Maximum (variable full cw)	Minimum (variable full ccw)
0 dB	10 V	1 V
−10 dB	3.2 V	320 mV
−20 dB	1 V	100 mV
−30 dB	320 mV	32 mV
−40 dB	100 mV	10 mV
−50 dB	32 mV	3.2 mV
−60 dB	10 mV	1 mV

7. Set the SYMMETRY control for desired asymmetry. The SYMMETRY control is used to develop ramp waveforms from the triangle, to vary the duty cycle of the square wave, to vary the ratio of rise/fall time of the trapezoidal waveform. Figure 2-4 shows the effect of this control on output waveforms. The output frequency is divided by approximately a factor of 10 when an asymmetrical waveform is selected.

8. When the trapezoidal waveform is selected, the WIDTH control is used to vary the duty cycle of the waveform and the SLOPE control is used to vary both rise and fall times. See Figure 2-5. Use the SYMMETRY control if asymmetrical rise and fall times are desired. See Figure 2-4.

9. Select the desired polarity of dc offset and the amount of offset using the DC OFFSET control. Offset voltage plus peak voltage cannot exceed the voltage range limit, ±5 volts in the 0 dB range. If an excessive amount of dc offset is used, waveform clipping may be observed (see Figure 2-6). Both signal and offset are attenuated by the attenuator.

2.5.2 Operation as a Voltage Controlled Generator

The VCG input connector can be used to externally control the frequency of the generator. If a positive voltage is applied to the VCG input terminal, the frequency will increase from the setting of the frequency controls. A negative voltage will cause the frequency to decrease from the setting of the frequency controls.

A 5 V excursion in VCG voltage can vary the frequency up to 1000:1 in each range as follows:

Range	Limits for Linear Operation	
	Lower	Upper
X0.001	0.003 mHz	0.003 Hz
X0.01	0.03 mHz	0.03 Hz
X0.1	0.3 mHz	0.3 Hz
X1	3 mHz	3 Hz
X10	30 mHz	30 Hz
X100	300 mHz	300 Hz
X1K	3 Hz	3 kHz
X10K	30 Hz	30 kHz
X100K	300 Hz	300 kHz
X1M	3 kHz	3 MHz
X10M	30 kHz	30 MHz

The upper limit may be exceeded as there is an overranging capability; however, overranging will be nonlinear and the operation is unspecified. Operation below the lower limit of any range setting is not recommended.

The nomograph of Figure 2-7 shows the characteristics of the VCG circuit. Column A gives the frequency dial setting, column B, the VCG voltage and column C, a factor representing the resultant frequency of the generator.

In example 1, the dial is set at 1.5 and no VCG input is applied. Extend a straight line from 1.5 (dial setting) thru 0 volt (VCG voltage). The result is an output frequency factor of 1.5. Multiply 1.5 by the range multiplier for actual 50Ω OUT frequency.

In order to set the generator at 0.003 X the range multiplier (1/1000 of the range), the following procedure is to be followed (Example 2):

1. Using the frequency dial and a counter or oscilloscope, set the generator frequency to 0.03 X the range multiplier.

2. By rotating the VERNIER ccw, decrease the frequency to 0.003 X the range multiplier.

As can be seen from the nomograph a +5 volt VCG input will then cause the frequency to increase to the maximum of 3 X the range (an increase from 0.003 X to 3 X is 1:1000).

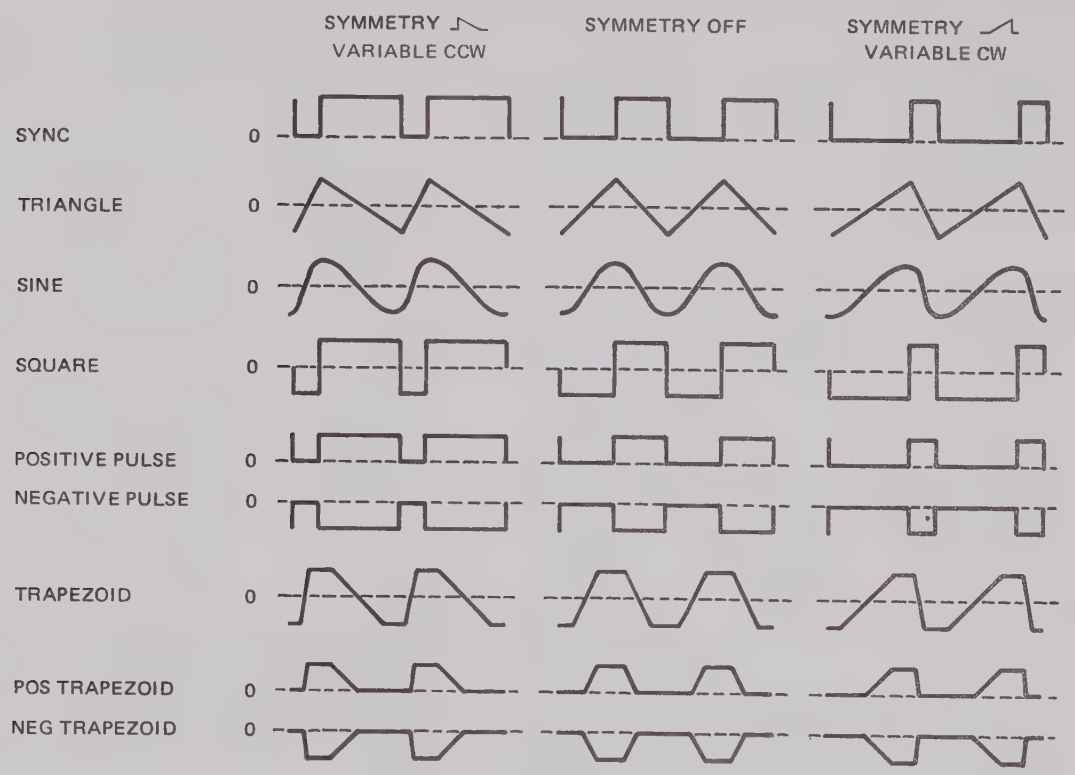


Figure 2-4. Effect of Symmetry Adjustment on Waveforms

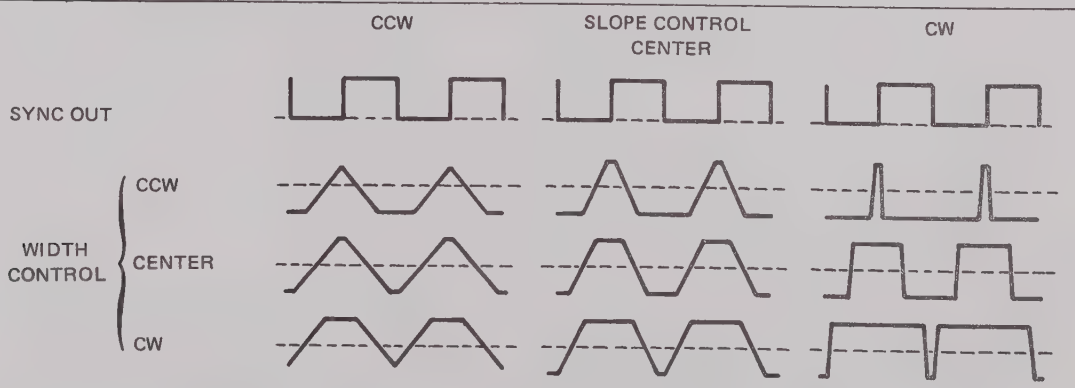


Figure 2-5. Effect of SLOPE/WIDTH Control on the Trapezoid Waveform

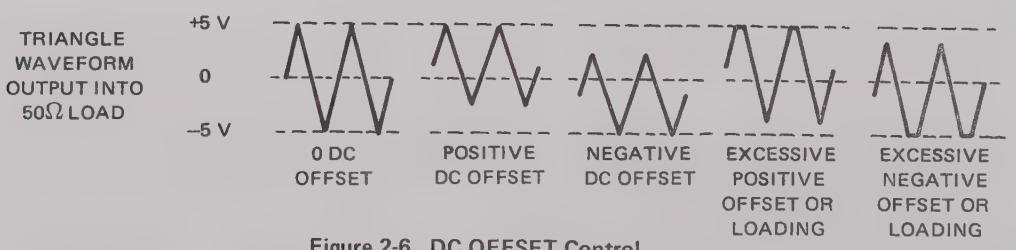


Figure 2-6. DC OFFSET Control

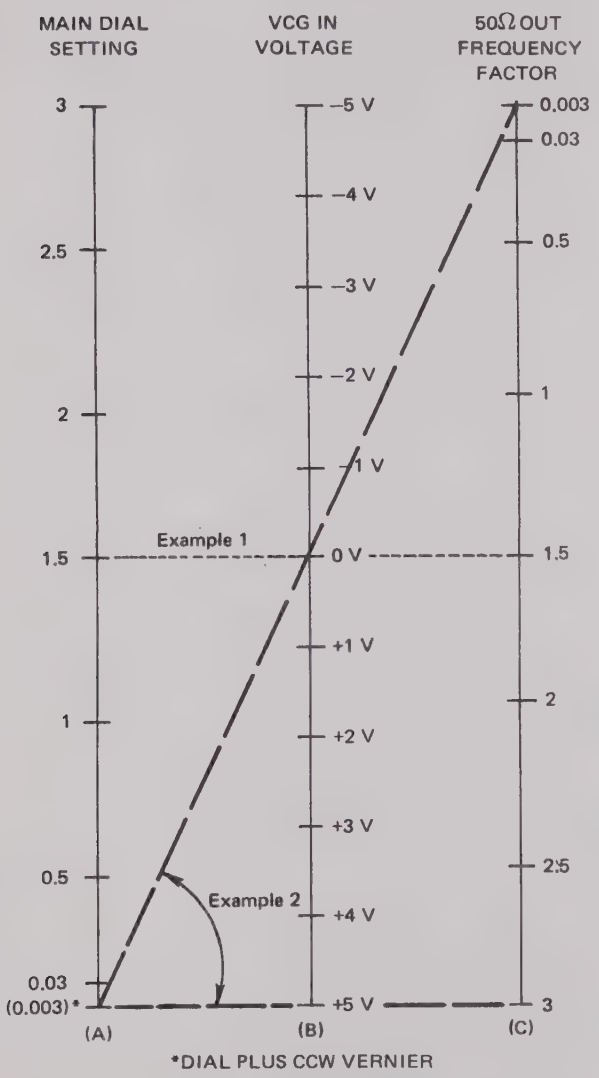


Figure 2-7. VCG Voltage-to-Frequency Nomograph

2.5.3 Operation as a Triggered Generator

1. Adjust the generator as for continuous operation (Paragraph 2.5.1); then set the GEN MODE switch to TRIG.

2. For external triggering, apply a repetitive signal, any waveform from 1 V p-p to less than ±50 V peak voltage (see TRIG IN specification, Paragraph 2.3, Item 22), to TRIG IN connector. Set the TRIG LEVEL control for proper triggering. See Figure 2-8 for the timing relationship of the trigger input, sync output and selected waveform output.

3. If manual triggering is desired, set the TRIG LEVEL control full ccw and operate the MAN TRIG switch for each cycle of selected output waveform.

NOTE

The SWEEP OUT connector may be used as a repetitive trigger source. In this case, the SWEEP/STEP TIME control determines the repetition rate of the triggered output signal.

2.5.4 Gated or Tone Burst Operation

With the generator adjusted as in trigger operation, change the GEN MODE control to GATED position. The generator output will then be a burst of cycles. If the trigger is the SWEEP OUT sawtooth waveform, the duration of the burst is adjustable by the TRIG LEVEL control (see Figure 2-8). Notice that the last cycle gated is completed at time t5, if the gate signal is removed between time t3 and t4. In manual gating, set TRIG LEVEL control full ccw. The tone burst continues as long as the manual switch is pressed.

The generator can be made to free run in this mode at certain settings of the trigger level control. By resetting the trigger level control, normal gated operation can be re-established.

2.5.5 Operation as a Sweep Generator

The second internal generator, the sweep generator, can modulate the main generator frequency in sweep or step fashion. The four modes, ramp up, ramp down, step up and step down, can be used in conjunction with the main generator modes as described in the next paragraphs.

2.5.5.1 SWEEP OUTPUT AND GENERATOR CONTROL VOLTAGE (GCV) OUTPUT

A fixed amplitude, 0 to $>$5 V, 600Ω impedance, ramp or staircase is provided at the SWEEP OUT connector. A voltage output, 0 to $>$ 5 V, 600Ω impedance, which is directly proportional to the main generator frequency is provided at the GCV OUT connector.

2.5.5.2 SETTING THE SWEEP FREQUENCY LIMITS

1. Set the SWEEP/STEP TIME switch to 100 ms or faster by monitoring SWEEP OUT.

2. Select the desired SWEEP MODE switch setting.

3. Set the GEN MODE switch to SWP HOLD.

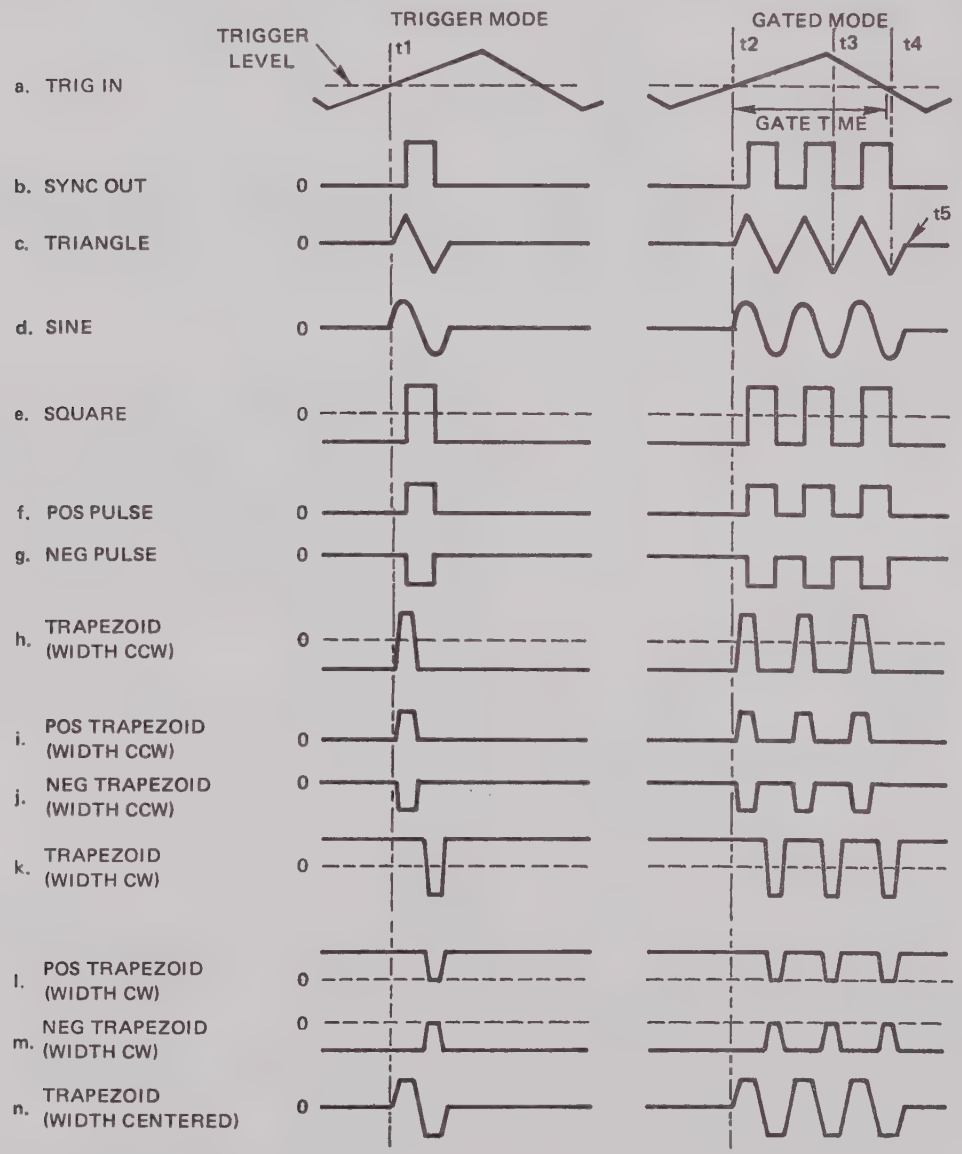


Figure 2-8. Trigger and Gated Operations

4. Set the TRIG LEVEL control full ccw.

5. Select the desired frequency range, using the FREQ (Hz) selector.

6. Set the desired sweep start frequency, using the frequency dial and VERNIER and monitoring the frequency at 50Ω OUT with an oscilloscope or counter.

7. Hold the MAN TRIG switch down; set the desired stop sweep frequency, using the SWEEP WIDTH control.

NOTE

Be sure this frequency does not exceed the range frequency limit; see Operating Frequency Range, Paragraph 1.2.2.

8. Sweep frequency limits are now set. Select the desired main generator mode using the GEN MODE switch. Notice that the generator frequency will sweep or step between the two limits when CONT SWP, TRIG SWP, SWP HOLD or SINGLE STEP is selected.

9. Select the desired SWEEP/STEP TIME.

2.5.6 Operation as a Continuous Sweep Generator

1. Select the desired SWEEP MODE switch setting and set up the sweep frequency limit as in Paragraph 2.5.5.2.

2. Set the GEN MODE switch to CONT SWP.

3. The proper waveform outputs at SWEEP OUT and GCV OUT are shown in Figure 2-9.

2.5.7 Operation as a Trigger Sweep Generator

1. Select the desired SWEEP MODE switch setting and set up the sweep frequency limit as in Paragraph 2.5.5.2.

2. Set the GEN MODE switch to TRIG SWP.

3. Connect a repetitive signal (see Trigger Input specification, Paragraph 1.2.9) to TRIG IN connector.

4. Adjust the TRIG LEVEL control for proper triggering.

5. The main generator will sweep from the start frequency to the stop frequency and reset back to start frequency for every cycle of the TRIG IN signal. However, if the trigger rate is faster than the sweep rate, the sweep generator will neglect all trigger signals during each cycle of sweep. See Figure 2-10.

6. Set the TRIG LEVEL control to full ccw if manual triggering is desired and operate the MAN TRIG switch for each cycle of sweep.

2.5.8 Operation as a Sweep and Hold Generator

1. Select the desired SWEEP MODE switch setting and set up the sweep frequency limit as in Paragraph 2.5.5.2.

2. Set the GEN MODE switch to SWP HOLD.

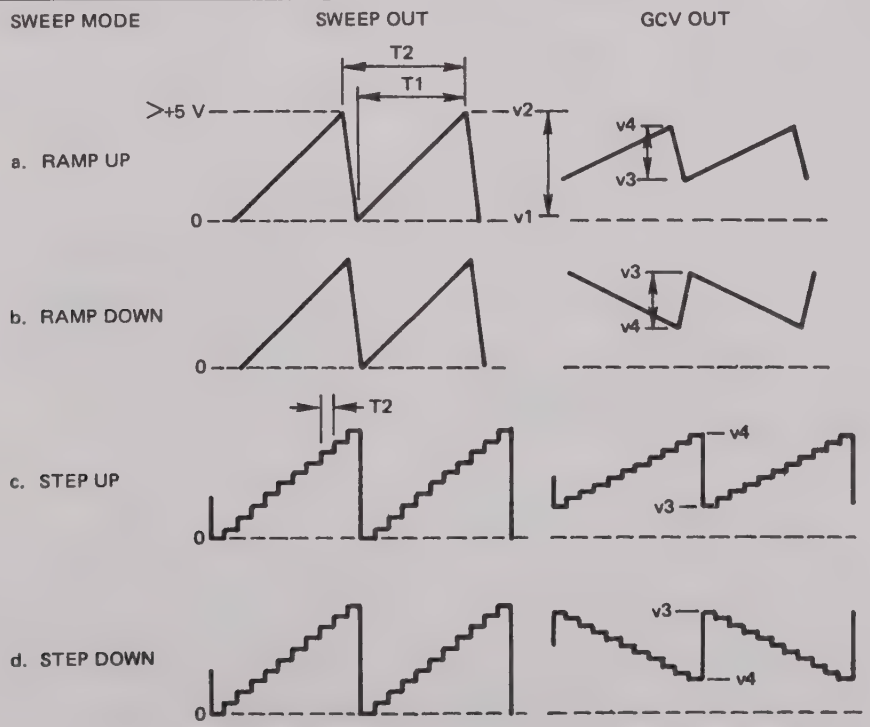
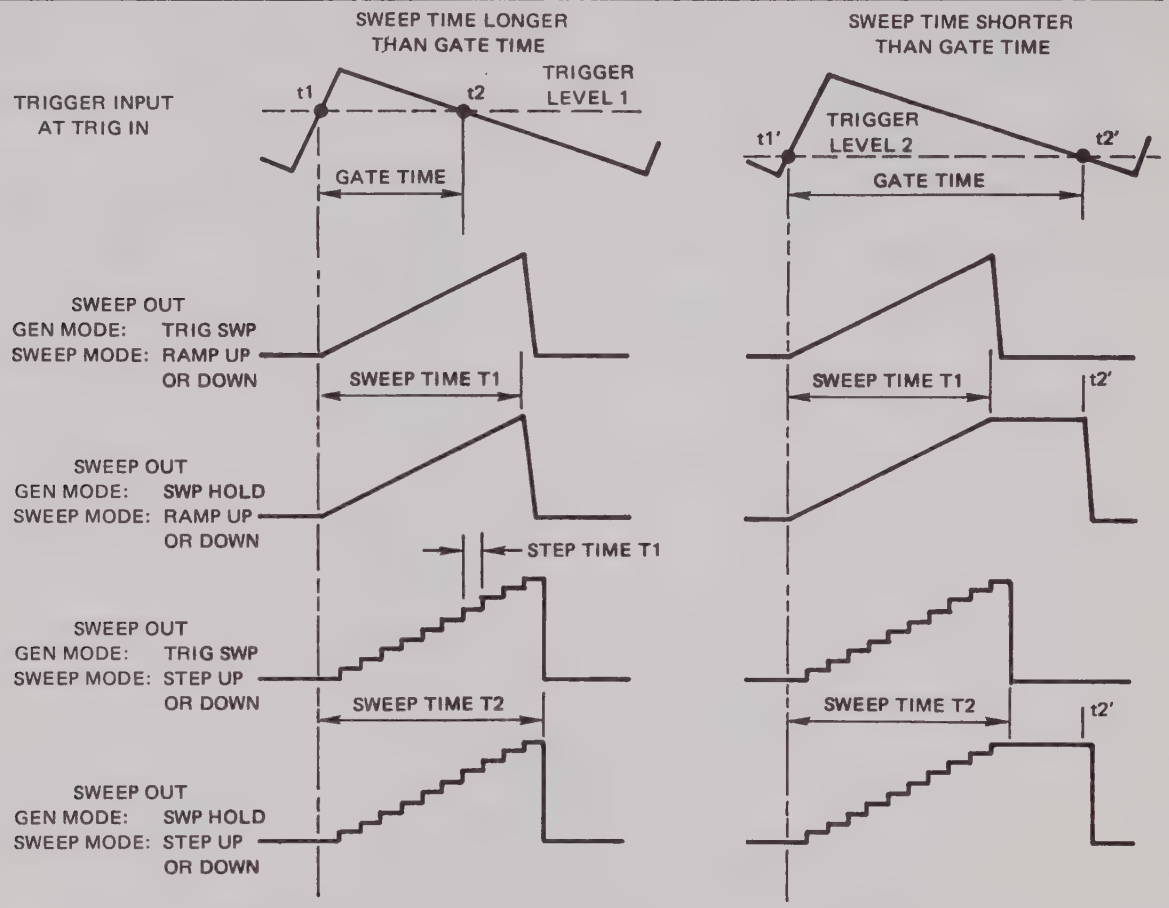


Figure 2-9. SWEEP OUT and GCV OUT at the Continuous Sweep Mode



NOTES

1. *T1 is the sweep time determined by the SWEEP/STEP TIME control setting when RAMP UP or RAMP DOWN is selected.*

2. *T2 is the time duration for each step and is also determined by the SWEEP/STEP TIME control setting when STEP UP or STEP DOWN is selected.*

3. *Voltage V3 is proportional to the sweep start frequency which is set by the frequency dial and VERNIER.*

4. *Voltage V4 is proportional to the sweep stop frequency. The voltage between V3 and V4 is proportional to the frequency range and is determined by the SWEEP WIDTH control setting.*

5. *Notice that the SWEEP OUT is always started from 0 volt to >+ 5 volts even if RAMP DOWN or STEP DOWN is selected. This is for the convenience of using it as the horizontal input signal of an oscilloscope or X-Y recorder.*

NOTE

The first step of staircase occurs after one "step time" delay from the start of gating signal, t1 and t1'. In the SWP HOLD mode, the staircase does not necessarily reset at time t2' when the gating signal is terminated, but at the time when first multiple "gate time" occurs after t2'.

Figure 2-10. Sweep Output for Triggered Sweep and Sweep-and-Hold Modes

3. Connect a repetitive signal (see TRIG IN specification, Paragraph 2.3, Item 22) to TRIG IN.

4. Adjust the TRIG LEVEL control for proper triggering.

5. The generator frequency will hold at its sweep stop frequency only if the gating time is longer than the sweep time. See Figure 2-10. Also the sweep generator will neglect all trigger input signals during a sweep cycle.

6. For manual triggering, set the TRIG LEVEL control full ccw and operate the MAN TRIG switch for each cycle of sweep.

2.5.9 Operation as a Single Step Generator

1. Select the desired STEP UP or STEP DOWN mode on the SWEEP MODE switch and set up the frequency limit as in Paragraph 2.5.5.2.

2. Set the GEN MODE switch to SINGLE STEP.

3. For maximum stepping rate (100 kHz), the SWEEP/STEP TIME control should be set at 100 μs | 10 μs with the VARIABLE full cw.

4. Connect a repetitive signal (see TRIG IN specification, Paragraph 2.3, Item 22) to TRIG IN connector.

5. Adjust the TRIG LEVEL control until the SWEEP OUT signal advances one step for every cycle of trigger input signal. See Figure 2-11.

6. If manual triggering is desired, set TRIG LEVEL to full ccw and operate MAN TRIG switch for each step.

2.5.10 Operation as a Sweep Burst Generator

1. Select the desired SWEEP MODE switch setting and set up the sweep limit as in Paragraph 2.5.5.2, except that the stop frequency should be set to approximately 10% beyond the desired stop frequency.

2. Set the GEN MODE switch to SWP BURST.

3. Connect a repetitive signal (see TRIG IN specification, Paragraph 2.3, Item 22) to TRIG IN as a gating signal. See Paragraph 2.5.4.

4. Adjust the TRIG LEVEL control for proper triggering.

5. For best results, the sweep limit should be set to longer than the duration of the burst to avoid the last-cycle transient due to the reset of the sweep signal. See Figure 2-12.

6. If the trigger rate is faster than the sweep rate, several sweep tone bursts can be generated during each sweep. If the trigger signal becomes a narrow pulse, an interesting signal can be generated as shown in Figure 2-13.

2.5.11 Synchronized Sweep Operation

Not only can the sweep generator be used to trigger the main generator, as in the case of TRIG or GATED mode of operation, but the main generator can also be used to trigger the sweep generator. The GEN MODE switch is set at TRIG SWP and triggered by the main generator (SYNC OUT connected to TRIG IN). The result is a continuous frequency sweeping signal but the sweep start is synchronized

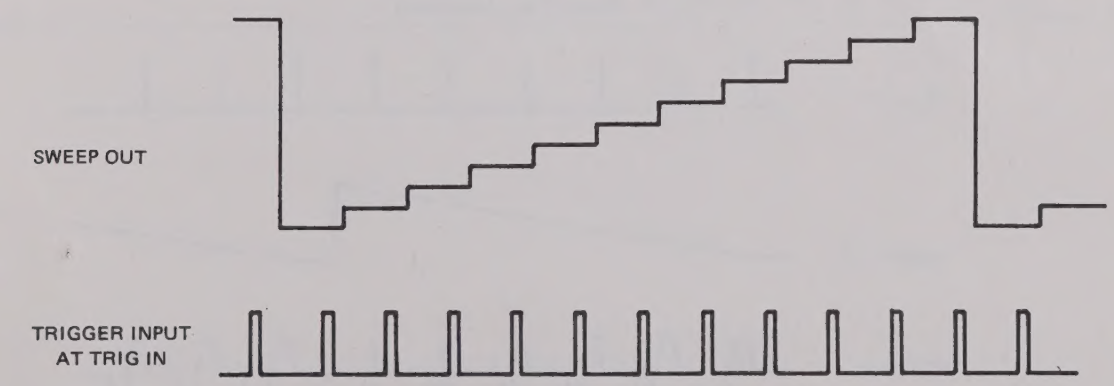


Figure 2-11. Single Step Mode Operation

to the main generator. Therefore, a stationary waveform display in oscilloscope is possible.

1. Set up the generator as in TRIG SWP mode. See Paragraph 2.5.7.
2. Connect SYNC OUT to TRIG IN with a coaxial cable.
3. Connect SWEEP OUT to the external trigger input of an oscilloscope and set the oscilloscope trigger to external and to negative trigger.
4. Adjust the TRIG LEVEL control of the generator until the output frequency is sweeping.
5. It may be necessary to adjust the generator SWEEP/STEP TIME slightly to obtain a stable display. For best results keep the ratio of main generator frequency less than 40:1.

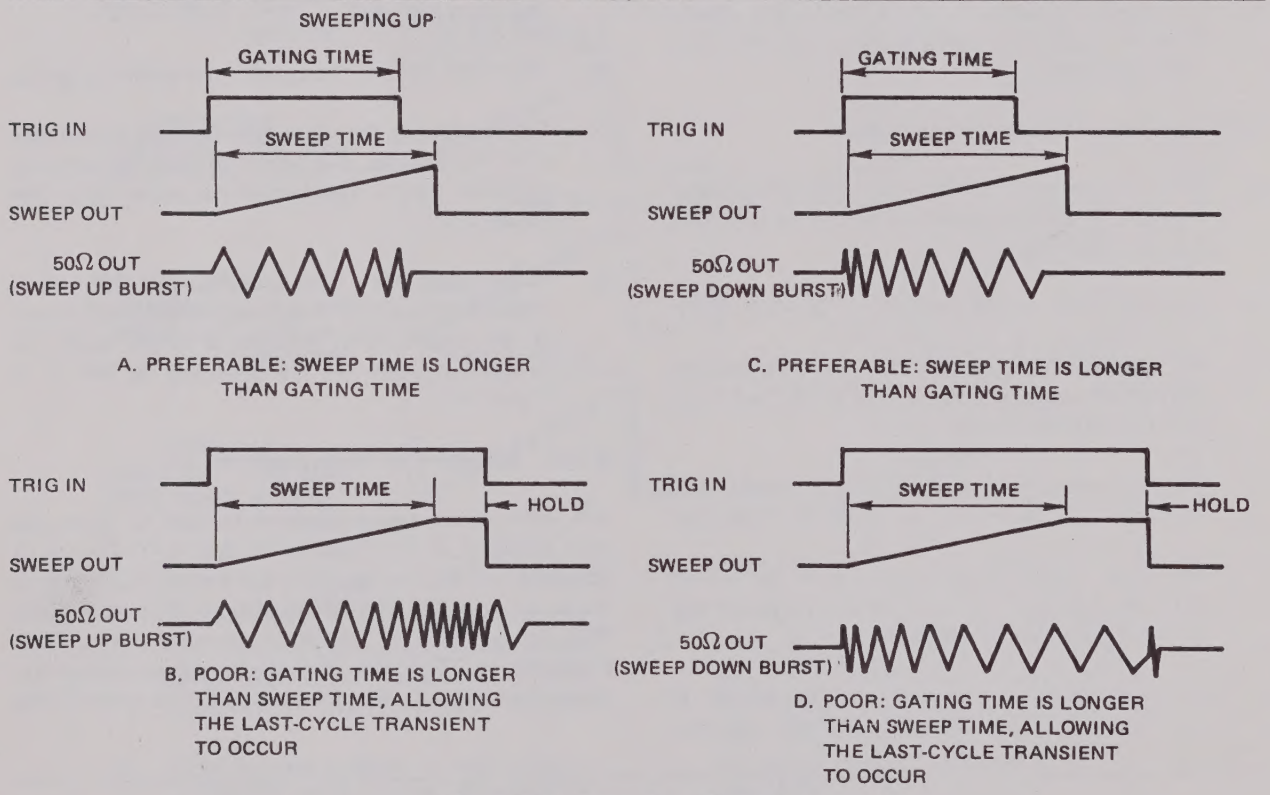


Figure 2-12. Sweep Burst Operation

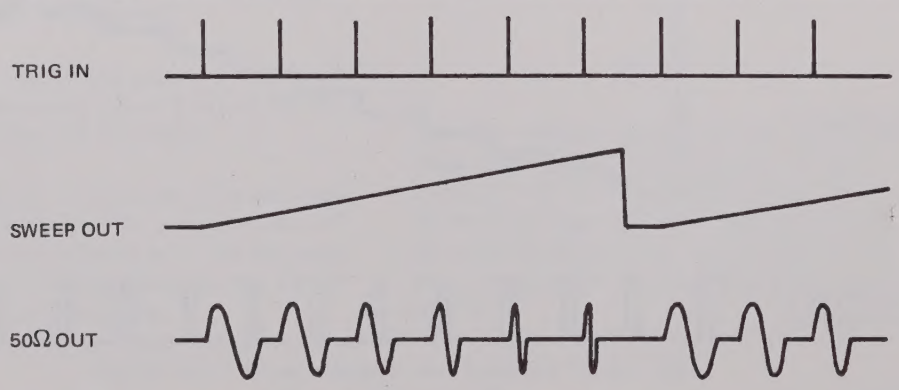


Figure 2-13. A Special Case of Sweep Burst Operation

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